Diet composition and variations of Morocco dentex *Dentex maroccanus* (Sparidae) from Eastern Algeria

by

Rima MOHDEB, Farid DERBAL & M. Hichem KARA* (1)

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Abstract. – Morocco dentex is an important commercial sparid fish on Algerian coasts, where its distribution is irregular. In two sites, Jijel and El Kala areas, located in the northeast of Algeria, 1725 specimens of *Dentex maroccanus* were caught and examined for diet composition study and trophic level estimation. Their total length (weight) ranged from 10.4 cm (16.05 g) to 26.8 cm (332.47 g). The Relative Importance Index (%IRI) was used to characterize the relative importance of the different food taxa, and their variations in the diet were studied according to season, sex and sexual maturity. Results from both sites were combined for analysis as no difference of vacuity index (VI: $\chi^2 = 0.048$, $p = 0.82$) and diet composition (correlation coefficient of Spearman: rho = 0.82, $t_{obs} = 4.61$, $p < 0.01$) was statistically observed between them. The average annual digestive vacuity was 22.85%. It did not vary according to sex and sexual maturity states ($\chi^2_{(\text{females, males})} = 0.04$, $p = 0.83$; $\chi^2_{(\text{immature, mature})} = 0.26$, $p = 0.6$), but differed significantly between seasons. *D. maroccanus* fed mainly on Pancrustacea (%IRI = 77.26%) and secondarily on Teleostei (%IRI = 21.85%), while Mollusca (%IRI = 0.87%) and Annelida (%IRI = 0.005%) were consumed accidentally. The mean trophic level (TROPH) of *D. maroccanus* was estimated at 3.91 (SE = 0.67) and varied with season, sex and sexual maturity state. A slightly lower TROPH value was observed in winter compared to the other seasons, while higher TROPH values were recorded in females than in males, and in mature than in immature individuals. According to this study, Morocco dentex is a carnivore with a marked preference for crustaceans and fish.

Résumé. – Composition et variations du régime alimentaire du denté du Maroc *Dentex maroccanus* (Sparidae) des côtes Est de l'Algérie.

Le denté du Maroc est un sparidé de grande importance commerciale sur les côtes algériennes. Dans les régions de Jijel et d'El Kala, situées dans le Nord-Est du pays, 1725 spécimens de *Dentex maroccanus* ont été capturés et analysés pour déterminer leur régime alimentaire et estimer leur niveau trophique. Leur longueur (poids) totale variait de 10,4 cm (16,05 g) à 26,8 cm (332,47 g). L'indice d'importance relative (%IRI) a été utilisé pour caractériser l'importance relative des différents groupes de proies, et leurs variations dans l'alimentation ont été étudiées en fonction de la saison, du sexe et de l'état de maturité sexuelle des individus. Les résultats obtenus dans les deux sites ont été traités ensemble, car aucune différence entre eux concernant l'indice de vacuité (VI: $\chi^2 = 0{,}048$; $p = 0{,}82$) et la composition du régime (coefficient de corrélation de Spearman: rho = 0,82; $t_{obs\,=}\,4{,}61$; $p < 0{,}01$) n'a été observée statistiquement. L'indice de vacuité moyen était de 22,85%. Il ne variait pas selon le sexe et l'état de maturité sexuelle des individus ($\chi^2_{(\text{femelles, mâles})} = 0{,}04$; $p = 0{,}83$; $\chi^2_{(\text{immatures, matures})} = 0{,}26$; $p = 0{,}6$), mais était significativement différent entre les saisons. *D. maroccanus s'*alimente principalement de Pancrustacea (%IRI = 77,26%) et secondairement de Teleostei (% IRI = 21,85%), tandis que les Mollusca (%IRI = 0,87%) et les Annelida (%IRI = 0,005%) ont été consommés accidentellement. Le niveau trophique (TROPH) moyen de *D. maroccanus* a été estimé à 3,91 (SE = 0,67) et variait selon la saison, le sexe et l'état de maturité sexuelle. Une valeur de TROPH légèrement plus faible a été observée en hiver par rapport aux autres saisons, tandis que des valeurs plus élevées ont été observées chez les femelles que chez les mâles, et chez les individus matures que chez les immatures. Selon cette étude, le denté du Maroc est un carnivore ayant une préférence marquée pour les crustacés et les poissons.

Morocco dentex, *Dentex maroccanus* Valenciennes, 1830, belongs to the Sparidae family (Bauchot and Hureau, 1986), which is represented in the Mediterranean Sea by 12 genera and 24 species, among which *Crenidens crenidens* (Forsskål, 1775) and *Rhabdosargus haffara* (Forsskål, 1775) are Lessepsian immigrants (Quignard and Tomasini, 2000). It is distributed in the eastern Atlantic, from the Bay of Biscay to the Gulf of Guinea and in the southern Mediterranean (Bauchot and Hureau, 1986). In Algeria, this species was found only in the eastern coasts (Hemida and Ghazli, 1998; Derbal and Kara, 2001). It is commonly found over various types of bottom from 40 to 200 m depth, especially fine sand (Maurin, 1962; Bauchot and Hureau, 1986), and can go down to 400 m (Tortonese, 1975). Hemida and Ghazli (1998) recorded individuals of 12-22 cm total length (TL) in depths of 40-200m in Algeria, while Maravelias *et al*. (2007) found this species at 50-70 m deep in the Aegean Sea. Bauchot (1987) estimated its maximal total length at 45 cm.

In the Mediterranean Sea, the total global production of *Dentex* sp. was estimated at 5,000 tons in 2011 (FishStatJ: http://www.fao.org/fishery/statistics/software/fishstatj/en). Morocco dentex has an important role in commercial fish-

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(1) Marine Bioresources Laboratory, Annaba University Badji Mokhtar, Algeria. [rimamohdeb@yahoo.fr] [mfderbal@yahoo.fr]
* Corresponding author [kara_hichem@yahoo.com]

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eries in Eastern Algeria, where its production is confused with the common pandora *Pagellus erythrinus* (Linnaeus, 1758) in the statistics of fishing (Ministry of Agriculture, Rural Development and Fishing, pers. comm.), which indicates that these two species are the most abundant demersal fish after *Mullus* spp. Their annual mean production was 945 tons between 2005 and 2011. According to the results of the investigations made in three ports of eastern Algeria, the production of *D. maroccanus* was estimated at 30% (mean: 336 tons in 2011 and 259 tons in 2012) of the two species.

The biology of *D. maroccanus* was mainly studied in the Atlantic by Loc and Wojciechowski (1972) in the North West of Africa, and by Lamrini and Bouymajjane (2002) on Moroccan coasts. In the Mediterranean, published information on this species is scarce and it is considered as data deficient in the IUCN Red List of marine fishes of the Mediterranean (Abdul Malak *et al.*, 2011). Growth and reproduction were studied in North Africa (Chemmam-Abdelkader *et al.*, 2002, 2004; Mohdeb and Kara, 2015) and in the Aegean Sea (Gul *et al.*, 2014). However, its diet remains insufficiently known both in Atlantic and Mediterranean. Only Chemmam-Abdelkader *et al.* (2004) analysed the feeding habits of this species on Tunisian coasts.

Part of a broader research program devoted to the feeding habits of coastal sparids from Algeria (Chaoui *et al.*, 2005; Derbal and Kara, 2006, 2008; Derbal *et al.*, 2007; Benchalel *et al.*, 2010), this study aims at describing the feeding activity, diet composition and trophic level variations of *D. maroccanus* in Eastern Algeria. These data are needed for the comprehension of the ecology and behaviour of this species, and its trophic interactions with other species in the area.

MATERIALS AND METHODS

A total of 1,725 specimens were collected monthly between June 2011 and May 2012, from two coastal sites of the Eastern Algeria, Jijel (36°50’07.3”N, 5°59’18.2”E) and El Kala (37°00’07.6”N, 8°18’42.2”E) (Fig. 1), where TL is the total length and TW is the total weight. Fish were sampled randomly from wholesalers and fishmongers, after ensuring that they originate from the fisheries of the study area. They were caught by trawls (during the night generally) and hand lines (during the day). Fish were kept in ice immediately after capture until dissection, which took place after some hours to a few weeks of freezing. For each fish, the sex was identified macroscopically according to the scale of gonad maturity proposed by Mohdeb and Kara (2015), the total length (TL) was measured to the nearest mm and the total weight (TW) recorded to the nearest g. Stomachs were extracted and were preserved in a neutral formalin solution (5%) until later examination. Individuals with reversed stomachs were not considered in this study.

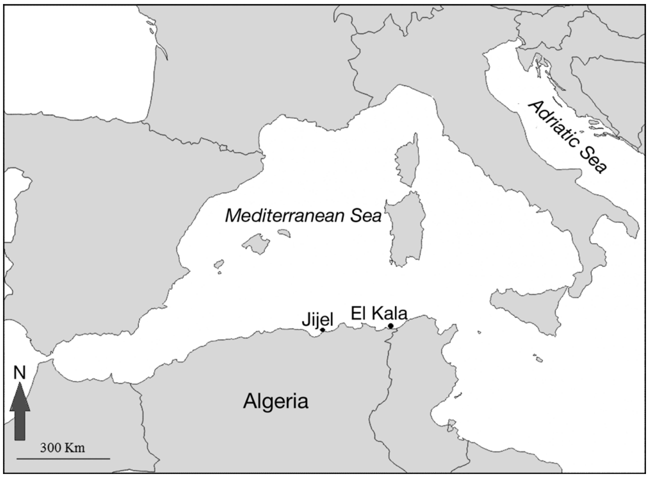

Figure 1. – Localisation of sampling sites of *Dentex maroccanus* on the eastern coasts of Algeria.

Each stomach was longitudinally sectioned, its contents collected then analysed under a binocular microscope. The food items were identified to the lowest possible taxonomic level, considering the type and digestion state of each prey. The percentage of empty stomachs was recorded and a vacuity index (VI) calculated globally and per season, sex and sexual maturity states.

Several indices were employed to analyse the general diet composition of fish (Hyslop, 1980): numerical proportion (%N), frequency of occurrence (%F) and weight (fresh weight) proportion (%W) were calculated for each prey item *i*; %Ni = (total number of prey item i / total number of prey items of all taxa) × 100; %Fi = (number of stomachs where prey i occurs / number of stomachs with food) × 100 and %Wi = (total weight of prey item i / total weight of prey items of all taxa) × 100. The main food items were identified using the index of relative importance (IRI) of Pinkas *et al.* (1971), modified by Hacunda (1981): IRI = %Fi (%Ni + %Wi). This index was expressed as %IRI = (IRI / Σ IRI) × 100, where Σ IRI was the sum of all prey indices. Prey species were

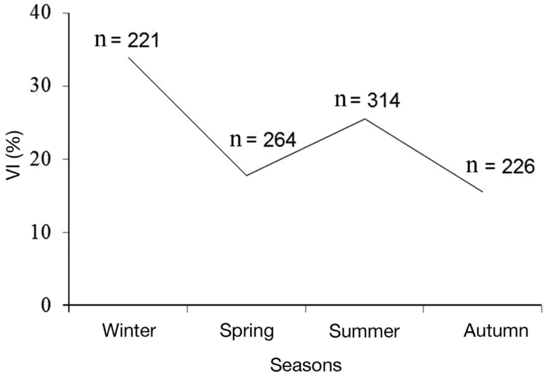

Figure 2. – Seasonal variations of vacuity index (VI) values in *Dentex maroccanus* on the eastern coasts of Algeria. n = sample size.

ranged in decreasing order according to their %IRI contribution and then cumulative %IRI was calculated. In this order, the %IRI of the first prey was gradually added until to obtain 50% or more; these items were considered as the main prey categories. This calculation was pursued until to get 75% or more; these next items were called secondary preys, while the remaining items were considered as accidental. Diet composition was compared statistically between the two sites (Jijel and El-Kala), using Chi-square test.

Variations in diet composition were compared according to season, sex and sexual maturity states. The statistical significance of these changes was evaluated by the Spearman correlation coefficient (Fritz, 1974), applied over the ranks occupied by the different prey. Statistical significance was tested with Student t-test (Dagnelie, 1975).

Statistical differences ($p < 0.05$) of vacuity index and diet composition according to site, season, sex and sexual maturity state were assessed by a Chi-square test (Sokal and Rohlf, 1987) applied on the frequency of a given prey. A multivariate analysis of variance (MANOVA) was also used to examine the association between diet composition (IRI value of each item) and season, sex and sexual maturity state. These tests were performed using SPSS 21 software (Anonymous, 1997).

The diet composition data was used for Morocco dentex trophic level values estimation. For species i, this value is: $\mathrm{TROPH}i = 1 + \sum_{i=1}^{G} (\mathrm{DC}ij \times \mathrm{TROPH}j)$ (Pauly *et al.*, 1998), where $\mathrm{TROPH}j$ is the fractional trophic level of prey j, $\mathrm{DC}ij$ represents the fraction of j in the diet of i and G is the total number of prey species. Trophic level and standard errors (SE) values were estimated for the overall population (seasons and sexes combined), for each season separately (sexes combined), females ($\mathrm{TROPH}_{\mathrm{female}}$) and males ($\mathrm{TROPH}_{\mathrm{male}}$) separately (seasons combined), and for immature ($\mathrm{TROPH}_{\mathrm{immature}}$) and mature individuals ($\mathrm{TROPH}_{\mathrm{mature}}$) (seasons and sexes combined), using the standalone Microsoft Access routine for estimating trophic levels "TrophLab" (Pauly *et al.*, 2000), downloadable from http://www.fishbase.org/Download/index2.htm.

RESULTS

A total of 924 individuals were analysed at Jijel ($10.4 \leq \mathrm{TL} \leq 26.8$ cm; $18.33 \leq \mathrm{TW} \leq 332.47$ g) and 799 at El-Kala ($10.5 \leq \mathrm{TL} \leq 26.5$ cm; $16.05 \leq \mathrm{TW} \leq$

Table I. – Prey composition in the diet of *Dentex maroccanus* of the eastern coast of Algeria and classification of prey according to the percentage of importance relative index. %N: numerical percentage; %W: weight percentage; %F: frequency; %IRI: relative importance index.

Items	%N	%W	%F	IRI	%IRI
PANCRUSTACEA	72.767	51.67	41.624	5179.602	77.261
Decapoda	67.865	50.274	38.832	4587.618	68.431
Decapoda macrura	50	40.37	26.396	2385.406	35.582
Palaemonidae	3.268	7.795	1.269	14.039	0.209
Palaemon serratus	2.941	7.285	1.142	11.68	0.174
Palaemonidae nd	0.327	0.51	0.127	0.106	0.002
Penaeidae nd	0.871	0.843	0.888	1.523	0.023
Decapoda caridea	33.987	21.841	15.736	878.503	13.104
Alpheidae	8.606	5.953	4.949	72.052	1.075
Alpheus glaber	3.268	2.546	2.284	13.281	0.198
Alpheus macrocheles	0.109	0.029	0.127	0.017	< 0.001
Alpheus sp.	1.198	0.918	0.508	1.074	0.016
Athanas sp.	0.436	0.278	0.254	0.181	0.003
Alpheidae nd	3.595	2.181	1.777	10.262	0.153
Caridae nd	25.381	15.888	10.787	445.163	6.64
Decapoda macrura nd	11.874	9.892	8.503	185.063	2.76
Decapoda anomoura nd	0.218	0.09	0.254	0.078	0.001
Decapoda brachyura	17.647	9.814	12.183	334.548	4.99
Portunidae	1.198	0.843	1.269	2.59	0.039
Galatheidae	0.109	0.13	0.127	0.03	< 0.001
Ghalathea sp.	0.109	0.13	0.127	0.03	< 0.001
Ocypodidae	2.07	1.176	1.523	4.943	0.074
Decapoda brachyoura nd	14.27	7.664	9.264	203.201	3.031
Peracarida	1.743	0.542	0.888	2.029	0.03
Isopoda	0.872	0.334	0.508	0.305	0.004
Sphaeromatidae	0.545	0.127	0.254	0.171	0.003
Sphaeroma serratum	0.109	0.075	0.127	0.023	< 0.001
Sphaeromatidae nd	0.436	0.052	0.127	0.062	0.001
Peracarida nd	0.327	0.081	0.127	0.052	0.001
Mysidacea	0.436	0.023	0.127	0.058	0.001
Cephalocarida	0.218	0.058	0.254	0.07	0.001
Squillidae	0.109	0.029	0.127	0.017	< 0.001
Squilla mantis	0.109	0.029	0.127	0.017	< 0.001
Cephalocarida nd	0.109	0.029	0.127	0.017	< 0.001
Amphipoda	0.327	0.017	0.127	0.044	0.001
Pancrustacea nd	2.179	0.756	1.396	4.097	0.061
TELEOSTEI	21.895	42.259	22.843	1465.451	21.859
Clupeidae	1.743	8.658	2.03	21.119	0.315
Engraulis encrasicolus	0.218	0.516	0.254	0.186	0.003
Sardina pilchardus	0.327	1.199	0.381	0.581	0.009
Sardinella aurita	0.218	2.181	0.254	0.609	0.009
Clupeidae nd	0.98	4.762	1.142	6.559	0.098
Caproidae	0.218	1.072	0.127	0.164	0.002
Capros aper	0.218	1.072	0.127	0.164	0.002
Nettastomatidae nd	0.109	0.235	0.127	0.044	0.001
Gobiidae nd	0.109	0.09	0.127	0.025	0.0004

Table I. – Continued.

Items	%N	%W	%F	IRI	%IRI
Carangidae nd	0.109	0.637	0.127	0.095	0.001
Teleostei nd	19.608	31.567	20.305	1039.09	15.5
MOLLUSCA	4.902	5.84	5.457	58.615	0.874
Cephalopoda	2.941	5.014	3.173	25.239	0.376
Loliginidae	0.436	1.176	0.508	0.818	0.012
Octopodidae	0.871	1.781	1.015	2.693	0.04
Octopus sp.	0.327	1.208	0.381	0.584	0.009
Octopodidae nd	0.545	0.574	0.635	0.71	0.011
Sepiolidae	0.218	0.614	0.254	0.211	0.003
Cephalopoda nd	1.416	1.443	1.396	3.99	0.06
Gastropoda	1.961	0.826	2.284	6.365	0.095
Rissoidae	0.545	0.345	0.635	0.564	0.008
Hydrobiidae	0.109	0.032	0.127	0.018	< 0.001
Turitellidae	0.327	0.119	0.381	0.17	0.003
Turitella sp.	0.327	0.119	0.381	0.17	0.003
Gastropda nd	0.98	0.33	1.142	1.497	0.022
ANNELIDA	0.436	0.232	0.508	0.339	0.005
Polychaeta	0.109	0.072	0.127	0.023	< 0.001
Annelida nd	0.327	0.159	0.381	0.158	0.003

300.84 g). Among the 1,725 sampled fish, 700 (40.58%) had reversed stomach, and were removed from our study. Samples from the two studied sites were first analysed separately. No statistical difference between sites was observed for global vacuity index ($VI_{Jijel} = 22.85\%$; $VI_{El\text{-}Kala} = 23.43\%$; $\chi^2_{(Jijel,\ El\text{-}Kala)} = 0.048$; $p = 0.82$), %Ni values of all items other than Annelida, due to their small number ($\chi^2_{Ni} = 3.41$, $p = 0.18$) and for the %IRI of each item ($\chi^2_{Teleostei} = 0.79$, $p = 0.37$; $\chi^2_{Pancrustacea} = 0.035$, $p = 0.85$; $\chi^2_{Mollusca} = 1.92$, $\varrho = 1.65$; $\chi^2_{Annelida} = 0.33$, $p = 0.56$). These results were confirmed by the correlation coefficient of Spearman (rho = 0.82, $t_{obs} = 4.61$, $p < 0.01$) that indicated a similar diet composition between the sites. Then, samples from both sites were combined in the following analysis.

Of the 1,025 examined stomachs, 236 were empty (VI = 23.1%). The vacuity index reached its maximum (42.9%) during January and its minimum (9.0%) in October. This percentage varied significantly with season, a minimum proportion of empty stomachs was found in spring (17.8%) and a maximum was found in winter (33.9%), while for samples collected in summer and autumn, vacuity index was 25.5% and 15.5%, respectively (Fig. 2). Statistical comparison by Chi-square test showed significant differences between each two seasons ($\chi^2_{(winter,\ spring)} = 16.63$, $p = 4.10^{-5}$; $\chi^2_{(winter,\ summer)} = 4.51$, $p = 0.034$; $\chi^2_{(winter,\ autumn)} = 20.5$, $p = 5.10^{-6}$; $\chi^2_{(spring,\ summer)} = 4.92$, $p = 0.026$; $\chi^2_{(summer,\ autumn)} = 7.82$, $p = 0.005$), except between spring-autumn ($\chi^2_{(spring,\ autumn)} = 0.46$, $p = 0.49$). However, the proportion of empty stomachs did not vary significantly between females and males ($VI_{female} = 22.42\%$; $VI_{male} = 21.9\%$; $\chi^2_{(females,\ males)} = 0.04$, $p = 0.83$) and between immature and mature individuals ($VI_{immature} = 24.0\%$; $VI_{mature} = 22.6\%$; $\chi^2_{(immature,\ mature)} = 0.26$, $p = 0.6$).

A total of 819 prey was identified, for an overall weight of 348.9 g. Average number and weight of prey was 1.6 and 0.38 g per full stomach, respectively. The stomach contents of *D. maroccanus* consisted of several prey species belonging to the following taxa: Teleostei, Pancrustacea (Decapoda, Brachyura, Peracarida, Mysida, Cephalocarida, Amphipoda, Isopoda), Mollusca (Cephalopoda, Gastropoda) and Annelida (Polychaeta). Table I presents the quantitative indices calculated for the different prey groups or species found in all stomachs combined. According to the %IRI, Pancrustacea were the most important ingested prey, constituting 77.26% of the total IRI, in particular Decapoda (%IRI = 68.43%) including Macrura (%IRI = 35.58%) and Brachyura (%IRI = 5%). *D. maroccanus* preyed secondarily on teleosts (%IRI = 21.85%) whose indeterminate teleosts were %IRI = 15.49%. Mollusca (%IRI = 0.87%) and Annelida (%IRI = 0.005%) were consumed accidentally.

Only slight seasonal variations were observed in the food habits of *D. maroccanus* in the studied area. Crustaceans remained the dominant prey group during all seasons (%IRI > 72%), particularly in winter (%IRI = 83.41%). Teleosts were consumed throughout the year, with a peak value recorded in autumn (%IRI = 26.5%) and a minimum in winter (%IRI = 15.90%). Molluscs were also present in the contents at all seasons, but in small quantity, while annelids were occasional and not found in spring. Significant differences among seasons were found for molluscs ($\chi^2 = 9.9$, $p = 0.01$) and annelids ($\chi^2 = 54.45$, $p = 8.92 \times 10^{-12}$), while no significant seasonal differences were found for crustaceans ($\chi^2 = 3.85$, $p = 0.27$), and teleosts ($\chi^2 = 4.41$, $p = 0.22$) (Tab. II). However, the Spearman correlation coefficient and MANOVA (Hotelling's $T^2 = 0.15$; $F = 0.72$; $p < 0.05$) indicated no statistical difference in the order of prey importance between seasons.

Females and males consume an average number of 1.58 and 1.75 preys corresponding to 0.39 g and 0.33 g per full stomach, respectively. For both sexes, diet was composed mainly by Pancrustacea ($\%IRI_{female} = 72.94\%$, $\%IRI_{male} = 80.84\%$, $\chi^2 = 2.91$, $p = 0.88$), followed by Teleostei ($\%IRI_{female} = 26.57\%$, $\%IRI_{male} = 15.95\%$, $\chi^2 = 3.58$, $p = 0.58$). Mollusca ($\%IRI_{female} = 0.47\%$, $\%IRI_{male} = 1.2\%$) were accidental preys, well as Annelida ($\%IRI_{female} = 0.01\%$, $\%IRI_{male} = 0.019\%$,) (Tab. III). Spearman correlation coefficient (rho = 0.81, $t_{obs} = 4.21$, $p < 0.01$) and MANOVA (Hotelling's $T^2 = 0.19$; $F = 1.91$; $p < 0.05$) confirmed that

Table II. – Variations in the diet of *Dentex maroccanus* according to seasons. Nm: mean number of prey per stomach; Wm: mean prey weight per stomach. See other abbreviations in table I.

Items	Winter					Spring					Summer					Autumn				
	%N	%W	%F	%IRI	Rank	%N	%W	%F	%IRI	Rank	%N	%W	%F	%IRI	Rank	%N	%W	%F	%IRI	Rank
PANCRUSTACEA	72.38	64.66	47.95	83.41	–	71.79	51.93	41.01	78	–	68.89	47.23	35.9	72.51	–	76.98	38.36	44.5	72.95	–
Macrura	53.59	53.65	30.14	41.03	1	40.6	34.05	23.96	27.5	1	50.67	36.03	21.79	32.87	1	55.04	32.22	31.94	39.61	1
Anomoura	0.55	0.18	0.68	0.01	7	–	–	–	–	9.5	–	–	–	–	9	0.36	0.14	0.52	0.004	9
Brachyura	16.57	10.11	15.07	5.11	3	24.79	16.05	14.29	8.97	3	15.56	9.9	11.54	5.11	3	14.03	3.96	8.38	2.14	3
Peracarida	1.1	0.55	1.37	0.03	6	5.56	1.56	1.84	0.2	5	0.44	0.21	0.43	0.005	5	–	–	–	–	11
Mysidacea	–	–	–	–	9.5	–	–	–	–	9.5	–	–	–	–	9	1.44	0.1	0.52	0.01	5
Cephalocarida	–	–	–	–	9.5	0.43	0.14	0.46	0.004	7	–	–	–	–	9	0.36	0.12	0.52	0.004	10
Amphipoda	–	–	–	–	9.5	–	–	–	–	9.5	–	–	–	–	9	1.08	0.07	0.52	0.01	7
MOLLUSCA	5.52	2.11	6.85	0.66	-	5.13	4.47	5.07	0.75	-	5.33	14.85	4.7	1.65	-	3.96	2.59	5.76	0.54	-
Cephalopoda	2.76	1.13	3.42	0.17	4	4.27	3.91	4.15	0.52	4	4.89	14.73	4.27	1.46	4	0.36	1.02	0.52	0.01	6
Gastropoda	2.76	0.98	3.42	0.16	5	0.85	0.56	0.92	0.02	6	0.44	0.13	0.43	0.004	6	3.6	1.58	5.24	0.38	4
TELEOSTEI	20.99	32.77	23.29	15.9	2	23.08	43.59	20.74	21.25	2	25.33	37.85	23.5	25.83	2	18.71	58.73	24.08	26.51	2
ANNELIDA	1.1	0.45	1.37	0.03	9.5	–	–	–	–	9.5	0.44	0.06	0.43	0	9	0.36	0.31	0.52	0	8
Nm	1.57					1.61					1.5					1.95				
Wm	0.61					0.3					0.38					0.29				

the main prey types were the same between the two sexes. However, at the family or specific level, differences were observed between males and females. Males targeted many families of Teleostei (Caproidae, Nettastomatidae, Gobidae), Pancrustacea (Galathae, Isopoda, Sphaeromatidae, Cephalocarida) and Mollusca (Sepiolidae). Females consumed rather Carangidae (Teleostei), Mysida, Squillidae and Amphipoda (Pancrustacea), Hydrobiidae (Mollusca) and non-identified Annelida.

Immature individuals of *D. maroccanus* (TL < 15 cm) (Mohdeb and Kara, 2015) consume more preys than mature ones in average number ($N_{\text{immature}} = 1.83$, $N_{\text{mature}} = 1.51$), and less in average weight per full stomach ($W_{\text{immature}} = 0.19$, $W_{\text{mature}} = 0.51$). Their diet was composed mainly by Pancrustacea ($\%IRI_{\text{immature}} = 82.52\%$, $\%IRI_{\text{mature}} = 75.04\%$, $\chi^2 = 1.9$, $p = 0.16$), followed by Teleostei ($\%IRI_{\text{immature}} = 16.36\%$, $\%IRI_{\text{mature}} = 24.12\%$, $\chi^2 = 2$, $p = 0.15$). Mollusca ($\%IRI_{\text{immature}} = 1.09\%$, $\%IRI_{\text{mature}} = 0.82\%$) and Annelida ($\%IRI_{\text{immature}} = 0.014\%$, $\%IR_{\text{mature}} = 0.002\%$) were accidental preys (Tab. IV). In contrast to immature individuals, mature ones target Caproidae, Nettastomatidae, Gobiidae, Carangidae (Teleostei), Palaemonidae (Decapoda Macrura), Galatheidae (Decapoda Brachyura), Anomoura, Peracarid and Cephalocarida (Pancrustacea). Juveniles consumed Hydrobiidae (Gastropoda) and Polychetae (Annelida) that were not consumed by the adults. However, the Spearman correlation coefficient ($rho = 0.71$, $t_{obs} = 3.07$, $p < 0.01$) and MANOVA (Hotelling's $T^2 = 0.14$; $F = 1.4$; $p < 0.05$) indicated that the importance order of the main prey types was similar between them.

The mean trophic level value of *D. maroccanus* was estimated at 3.91 (SE = 0.67). Seasonal variations of TROPH showed a maximum of 3.94 in summer and autumn (SE = 0.68 for each of them), followed by a TROPH of 3.92 (SE = 0.67) in spring, and the minimum was estimated at 3.82 (SE = 0.65) in winter. The TROPH value was slightly lower in males (3.84 ± 0.65 SE) than in females (3.95 ± 0.68 SE), and in immature (3.84 ± 0.65 SE) than in mature (3.94 ± 0.68 SE) individuals.

DISCUSSION

The individuals of *D. maroccanus* from Jijel and El-Kala were analysed together, since the diet was similar in the two sites. In addition, the 700 reversed stomachs were removed from the analysis to avoid the risk of distorting the results. This phenomenon is the result of the breakdown of the swim bladder, caused by the fast expansion of the air prevalent in the abdomen (Arago *et al.*, 1847).

The VI value obtained in this study (23.12%) was relatively close to that estimated on Moroccan Atlantic coasts (29.41%) by Lamrini and Bouymajjane (2002) and high-

Table III. – Variations in the diet of *Dentex maroccanus* with sex. See abbreviations in tables I and II.

Items	Females					Males				
	%N	%W	%F	%IRI	Rank	%N	%W	%F	%IRI	Rank
PANCRUSTACEA	71.55	46.04	19.8	72.94	–	19.27	33.25	11.38	15.95	–
Macrura	51.59	38.15	12.78	35.95	1	74.54	60.9	22.92	82.84	1
Anomoura	0.21	0.06	0.11	0.001	10	49.54	45.67	14.62	37.13	7
Brachyura	15.71	7.27	5.88	4.24	3	0.23	0.14	0.15	0.001	3
Peracarida	0.64	0.15	0.11	0.003	7	19.04	12.89	6.31	5.37	6
Mysidacea	0.85	0.04	0.11	0.003	6	2.98	1.08	0.92	0.1	9
Cephalocarida	–	–	–	–	11	0.23	0.06	0.15	0.001	8
Amphipoda	0.64	0.03	0.11	0.002	8	0.23	0.07	0.15	0.001	9
MOLLUSCA	3.82	4.09	1.92	0.48	–	5.96	5.79	3.85	1.21	–
Cephalopoda	1.91	3.58	0.9	0.16	4	3.9	4.51	2.46	0.55	4
Gastropoda	1.91	0.51	1.02	0.08	5	2.06	1.28	1.38	0.12	5
TELEOSTEI	23.99	49.5	11.54	26.57	2	19.27	33.25	11.38	15.95	2
ANNELIDA	0.64	0.38	0.34	0.01	9	0.23	0.06	0.15	0.001	9
Nm	1.59					1.75				
Wm	0.4					0.34				

Table IV. – Variations in the diet of *Dentex maroccanus* according to maturity states. See abbreviations in tables I and II.

Items	Immature individuals					Mature individuals				
	%N	%W	%F	%IRI	Rank	%N	%W	%F	%IRI	Rank
PANCRUSTACEA	77.04	57.2	41.32	82.53	–	69.76	50.86	41.8	75.05	–
Macrura	53.03	38.91	28.47	38.95	1	47.87	40.21	25.2	33.04	1
Anomoura	0	0	0	0	10	0.37	0.11	0.4	0.003	7
Brachyura	19.79	16.64	10.07	5.46	3	16.14	9.23	13.4	5.06	3
Peracarida	0	0	0	0	10	2.97	0.68	1.4	0.08	6
Mysidacea	0	0	0	0	10	0.74	0.03	0.2	0.002	8
Cephalocarida	0.26	0.14	0.35	0.002	8	0.19	0.04	0.2	0.001	9
Amphipoda	0.79	0.08	0.35	0.005	6	0	0	0	0	10.5
MOLLUSCA	4.22	9	5.56	1.09	–	5.38	4.92	5.4	0.83	–
Cephalopoda	2.37	8.1	3.13	0.49	4	3.34	4.12	3.2	0.36	4
Gastropoda	1.85	0.9	2.43	0.1	5	2.04	0.79	2.2	0.09	5
TELEOSTEI	18.21	32.9	21.53	16.37	2	24.49	44.17	23.6	24.12	2
ANNELIDA	0.53	0.9	0.69	0.01	7	0.37	0.05	0.4	0.003	10.5
Nm	1.51					1.9				
Wm	0.51					0.19				

er than that recorded on Tunisian coasts by Chemmam-Abdelkader *et al.* (2004) (14.23%). The feeding rates of many demersal fish species decrease when the temperature drops and feeding intensity is negatively related to the percentage of empty stomachs (Tyler, 1971). Frehi *et al.* (2007) recorded the lowest temperature value in winter (T° = 15.8°C) in the study area, which corresponded to the highest VI value of *D. maroccanus* in same season (VI = 33.93%). In this study, differences of VI among seasons, between males and females, and immatures and adults, indicate that this predator is always in search of food. Comparing with other *Dentex* species, this percentage was estimated at 75.12% for *D. canariensis* Steindachner, 1881 on Mauritanian coasts in Atlantic (Cheikhna *et al.*, 2011), 79.08% for *D. dentex* (Linnaeus, 1758) and 72.24% for *D. gibbosus* (Rafinesque, 1810) on Tunisian coasts (Chemmam-Abdelkader *et al.*, 2004). According to Quiniou (1978), these low values of VI are a feature of voracious predators that may reflect the availability and frequency of prey in the study area.

The main prey of *D. maroccanus* in Eastern Algeria were Pancrustacea (77.26%) followed by Teleostei (21.85%) as secondary preys. Mollusca and Annelida composed accidental preys (%IRI < 1%). On the Tunisian coast, Morocco dentex prefers also Pancrustacea (72.8%), but followed by Mollusca (23%), especially Gastropoda (15.3%) (Chemmam-Abdelkader *et al.*, 2004). However, in Atlantic Morocco, their preferences are different from those from the Mediterranean: fish constitute the main biomass in their stomachs, followed by Amphipoda, Gastropoda, Cephalopoda, Decapoda and Polychaeta as frequent secondary preys (Lamrini and Bouymajjane, 2002). A seasonal phenomenon was observed by Cadenat (1954) during the analysis of some Morocco dentex stomachs from the West African coast, with the presence of a big amount of pyrosomes, along with crustaceans and molluscs. Because few studies were made on Morocco dentex feeding behaviour, its diet was compared to those of other species of the same genus studied in the Mediterranean. Morales-Nin and Moranta (1997) found that in the Balearic Islands, the adults of *D. dentex* feed mainly on coastal fishes (74 %) and on cephalopods (26 %) as secondary prey. The smaller individuals have ingested fish species from *Posidonia* meadows, like sparids and more frequently labrids. In larger specimens, fish were the predominant prey, mainly sparids, picarel and anchovy. Whole cephalopods, remains of sepia bone and unidentified beaks were also found (25.62%). In Tunisian waters, *D. dentex* feeds preferentially on fish (84%), crustaceans (9%), cephalopods (5%) and plant remains (2%) (Chemmam-Abdelkader *et al*., 2004). In the same area, *D. gibbosus* also feeds mainly on fish (81%), crustaceans (9%) and cephalopods (8%). The diet of *D. dentex* is close to that of *D. gibbosus*, but the two species feed differently from *D. maroccanus*. This can be the result of a difference in size, as *D. maroccanus* is the smallest species, with an asymptotic length of 37.3 cm in our study area (Mohdeb and Kara, 2015), while *D. dentex* and *D. gibbosus* can grow up to 97.1 cm and 103.5 cm in Tunisian coasts respectively (Chemmam-Abdelkader *et al*., 2004).

Despite the absence of significant difference in the relative importance of prey groups indicated by the Spearman rank coefficient and MANOVA, with the presence of Crustacea, Teleostei, Mollusca and Annelida in the diet during all seasons, some seasonal differences still existed. Spring diet was characterized by the most important consummation of Brachyura (%IRI = 8.96%), the autumnal one was characterized by the highest %IRI values of Teleostei (%IRI = 26.5%) and Gastropoda (%IRI = 0.38%) and in summer, the diet was characterized by the highest Cephalopoda %IRI value (%IRI = 1.46%) and a high consumption of Teleostei (%IRI = 25.84%). These changes could be the result of seasonal variations in prey abundance. No significant differences in the importance order of prey were observed between female and male diets, nor between immature and mature individuals. However, some slight differences existed with a higher consumption of Teleostei by the adults.

Global TROPH (3.91) corresponds to "carnivore with preference for decapods and fish" group in the classification of fishes based on their TROPH (Stergiou and Karpouzi, 2002). This classification is confirmed by %IRI values of these preys (%IRI Decapoda = 68.43%, %IRI Teleostei = 21.85%). TROPH value is close to that calculated for *D. dentex* in Tunisian coasts (4.5) (Stergiou and Karpouzi, 2002) and shows very low variations according to season (from 3.82 to 3.94), sex ($\text{TROPH}_{\text{females}} = 3.95$; $\text{TROPH}_{\text{males}} = 3.84$), and maturity states ($\text{TROPH}_{\text{immature}} = 3.84$; $\text{TROPH}_{\text{mature}} = 3.94$). Moreover, temperature values of seawater recorded by Frehi *et al*. (2007) during different seasons in the study area were positively correlated with seasonal TROPH values (r = 0.81), confirming the result of Karachle and Stergiou (2008) about the effect of season on trophic levels of marine fishes.

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